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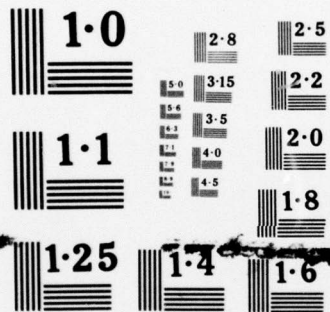
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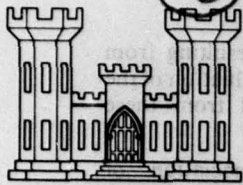


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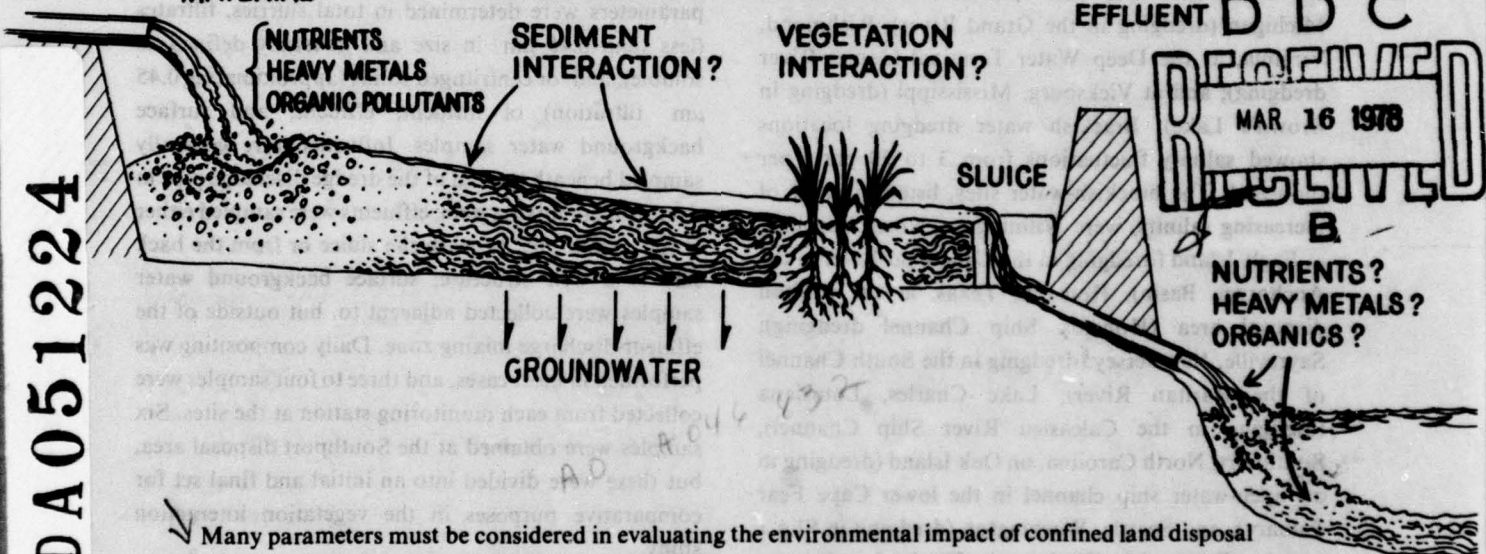
NOTES • NEWS • REVIEWS etc

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MATERIAL

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Many parameters must be considered in evaluating the environmental impact of confined land disposal of dredged material and predicting the chemical changes that may occur during retention of the slurry in the disposal area. This schematic represents some of the factors studied under the Dredged Material Research Program (DMRP) Work Unit 2D01, which is described in the following article.

STUDIES ASSESSING THE IMPACT OF LAND DISPOSAL OF DREDGED MATERIAL

INTRODUCTION

Legislation of the last several years has given the Corps of Engineers greater jurisdiction over lands adjacent to navigable waterways, including wetlands and drainage systems from upland areas. At this time, there is also increasing emphasis on the land disposal of especially highly contaminated or toxic dredged

material, promoted by growing concern about the pollution potential of open-water disposal operations. There have been only limited studies concerning the pollution potential and physical and chemical changes that are induced by the disposal of dredged material in land containment areas.

Some research has suggested that the mobility or availability of many harmful chemical constituents can be accentuated under the changing environmental conditions prevalent in confined disposal areas. However, other studies have failed to show any significant releases of contaminant species in disposal

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area effluent discharges. Due to the paucity of information available and conflicting findings, a comprehensive field study concerning the impact of land disposal was conducted under Work Unit 2D01 in Task 2D, Confined Disposal Area Effluent and Leachate Control, of the Environmental Impacts and Criteria Development Project (EICDP). The included studies were conducted by personnel at the Environmental Effects Laboratory, Waterways Experiment Station.

APPROACH

Nine confined land disposal areas were monitored in this study. The sites were chosen on the basis of high concentrations of contaminants in the dredged sediments, including oil and grease, chlorinated pesticides, PCB's, nutrients, and heavy metals.

Freshwater sites were located at Grand Haven, Michigan (dredging in the Grand River); Richmond, Virginia, at the Deep Water Terminal (James River dredging); and at Vicksburg, Mississippi (dredging in Brown's Lake). Brackish water dredging locations showed salinity fluctuations from 3 to 20 parts per thousand. The brackish-water sites, listed in order of increasing salinity, were Wilmington, North Carolina, at Eagle Island (dredging in the Cape Fear River at the Anchorage Basin); Houston, Texas, at the Clinton disposal area (Houston Ship Channel dredging); Sayreville, New Jersey (dredging in the South Channel of the Raritan River); Lake Charles, Louisiana (dredging in the Calcasieu River Ship Channel); Southport, North Carolina, on Oak Island (dredging in an open-water ship channel in the lower Cape Fear Estuary); and Seattle, Washington (dredging in Slip 1 on the Duwamish Waterway). Dredged sediments ranged from mixed coarse sand and gravel to predominantly silt and clay. The organic matter and sulfide contents fluctuated greatly in relation to the textural changes.

The study included many factors that could influence effluent water quality from land disposal areas:

- Effect of residence time of the dredged slurry in the containment area on effluent quality.
- Relation of dredged material texture and solids content to chemical release patterns.
- Interaction of vegetation in disposal areas with effluent quality.
- Determination of the changes in the chemical complexes associated with the particulate

matter in dredged material, resulting from disposal area retention, and evaluation of the contaminant release potential from these solid phase complexes.

- Determination of the association of contaminants with different sized particulate fractions in influent and effluent samples.
- Evaluation of the standard elutriate and diluted sediment pore water tests for predicting effluent water quality.

For comparative purposes, influent, effluent, and surface background water samples were obtained at each site. Several factors that could regulate effluent quality in land containment areas are depicted in the figure on the cover.

METHODS AND MATERIALS

More than 50 different physical and chemical parameters were determined in total slurries, filtrates (less than $0.45 \mu\text{m}$ in size and generally defined as soluble), and/or centrifuged solids (approximating $0.45 \mu\text{m}$ filtration) of influent, effluent, and surface background water samples. Influent samples were generally sampled beneath the end of the dredge discharge pipe in the turbulent mixing pool; effluents were sampled either at the outfall pipe beneath the sluice or from the back side of a weir structure; surface background water samples were collected adjacent to, but outside of the effluent-discharge mixing zone. Daily compositing was performed in most cases, and three to four samples were collected from each monitoring station at the sites. Six samples were obtained at the Southport disposal area, but these were divided into an initial and final set for comparative purposes in the vegetation interaction study.

Salinity, conductivity, dissolved oxygen (DO), slurry pH, and water temperature were measured in the field for influent, effluent, and background water samples; disposal area sediment pH and oxidation-reduction potential (Eh) were also measured at each site. Additional physicochemical parameters determined in the laboratory were particle size by mechanical analysis (percent sand, silt, clay), Coulter Counter analysis of the suspended particulates, total solids, nonfilterable solids, settleable solids, volatile solids, cation exchange capacity, alkalinity, and chemical oxygen demand (COD). The concentrations of 20 nutrients and metals determined included total and organic carbon; organic, ammonium, and nitrite-nitrate nitrogen; total and ortho-phosphate phosphorus; sulfide; calcium;

magnesium; potassium; sodium; iron; manganese; zinc; cadmium; copper; nickel; lead; mercury; chromium; titanium; vanadium; and arsenic. Chlorinated hydrocarbon determinations were made for PCB's, DDT, DDE, DDD, dieldrin, aldrin, lindane, heptachlor, heptachlor epoxide, and chlordane. Also, oil and grease, sulfate, and chloride measurements were made.

RESULTS AND CONCLUSIONS

Heavy Metals

Data comparisons of total acid digests for total influent and effluent samples from the disposal areas showed that most total (bulk analysis) concentrations of chemical constituents showed significant decreases during retention in land containment areas. Generally, the removal efficiency for most heavy metals closely paralleled the removal of the solids during dredged slurry containment in land disposal areas. However, different metals seem to have varying affinities for different particle sizes, and if the particulate phase passes through a 0.45- μ m filter (as do many colloidal forms), the associated metals will more than likely pass over the effluent weir, as well as be included as a soluble-phase constituent. Total mercury in effluent samples decreased by 46 percent, which indicates that it was often associated with the fine particulate fraction and/or one of low specific gravity (e.g., organic suspended solids). However, there was generally little variation in soluble mercury levels in influent, effluent, or surface background water filtrates. Other heavy metals that showed removal efficiencies less than for the solids removal were arsenic (85 percent) and titanium (89 percent). Soluble-phase arsenic (0.45 μ m filterable) was removed efficiently in the monitored land disposal areas.

The particulate fractionation of effluents from the Seattle site, which consisted mainly of oxidized iron hydrous oxide precipitates, also showed that appreciable quantities of some metals, especially chromium and potassium, were associated with particles that could pass through a 0.45- μ m filter. The mercury analyses, which used two methods (the cold vapor technique and high-temperature charring in a Zeeman spectrophotometer), also clearly showed that much of the filterable mercury was associated with very fine particulate matter. Thus, the filter size and the instrument employed for analyses are of great

importance in determining soluble-phase concentrations.

Chlorinated Hydrocarbons

Most of the chlorinated hydrocarbons (pesticides, PCB's) were efficiently removed by properly managed slurry retention in confined disposal areas. An exception was DDE. However, the dredging site water appeared to be the source for the DDE and not the bottom sediments, since comparable DDE concentrations were observed in surface background water samples. Oil and grease were removed efficiently during dredged slurry containment. However, sediments with high contents of petroleum residues seemed to settle more slowly, often creating highly fluid oil-water-sediment suspensions near the bottom of ponded areas. Poor disposal area management may result in the release of these suspensions, resulting in poor effluent quality.

Ammonium

Analytical data for influent and effluent sample filtrates showed that soluble-phase ammonium nitrogen was released in high concentrations from some bottom sediments. Ammonium release was most frequently directly related to organic nitrogen concentrations in the bottom sediments. Soluble-phase ammonium concentrations in disposal area influent samples averaged 20.8 mg/l with maximum levels of 70 mg/l. Generally, an equivalent amount of ammonium nitrogen was exchangeable from the influent solids; low solids effluents showed negligible exchangeable ammonium, despite a noticeable increase in the cation exchange capacity of effluent solids. A very rapid initial decrease in soluble-phase ammonium was noted in most sites displaying a short slurry detention. This was attributed to sorption by disposal area solids in contact with the slurry and was most pronounced in the presence of fine-grained sediments. Although 57 percent of the total ammonium nitrogen was removed from the dredged slurry during residency, effluent levels often remained at levels which could warrant concern. This is especially true if high pH conditions exist in the disposal area or discharge zone which promote the formation of highly toxic undissociated ammonia.

Effluent Levels Contrasted to Background Concentrations

Heavy metals that had a tendency to be released at

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above ambient background water concentrations in effluent filtrates included manganese, zinc, copper, chromium, titanium, and vanadium. High soluble-phase effluent manganese, which averaged 1.45 mg/l (maximum: 8 mg/l) resulted from high influent concentrations and often a poor removal efficiency. Copper and zinc had a tendency to increase in the soluble phase of dredged slurries during residency in disposal area, although there were only sporadic occurrences of effluent concentrations that would warrant concern. Chromium and titanium appeared to be associated mainly with filterable particulate matter in effluents from several sites.

Generally, the soluble-phase concentrations of most heavy metals were closely reflected by concentrations in respective background water samples. Total organic and ammonium nitrogen, phosphorus, and oil and grease were noticeably lower in background water samples. Parameters that were higher in the background surface water samples include DO (averaging 5.3 mg/l in effluents), nitrate + nitrite nitrogen, and op' DDE, with effluent samples containing 54, 49, and 13 percent of the background water levels, respectively. The pH of influents, effluents, and background water showed an increasing trend, with respective values of 6.6, 7.2, and 7.5.

Vegetation

The heavily vegetated Southport disposal area, although only about average in size (48 acres), elicited almost complete removal of visible suspended solids. The initial effluents, collected when only about 10 percent of the site was ponded and most of the slurry was migrating as overland flow through the plant growth, were of drinking water clarity with almost no visible turbidity. Effluents collected after most of the shorter vegetation had been buried and about half of the site was ponded showed a higher solids content, although it was also very low (0.17 mg/l) in nonfilterable solids.

Most of the effluent samples contained solids levels similar to the background surface water. Effluents from the unvegetated Seattle site also showed comparable solids removal. However, an organic polymeric flocculant was added to this two-compartment disposal area.

Ammonium nitrogen and soluble phosphorus seemed to be removed at above normal levels from the vegetated area at Southport, despite relatively high influent levels for each. Most of the trace metals in total

samples decreased in direct proportion with the nonfilterable solids removal. The very high effluent levels of soluble-phase zinc, cadmium, copper, and nickel at this site were reflected by equally high background water concentrations.

Residence Time

The overall effect of residence time on effluent water quality could not be properly evaluated. However, the data indicated that other variables (e.g., organic matter content) were more important. Increased residence time may affect various important physicochemical variables in divergent ways, with either uniform or fluctuating changes (e.g., for pH, Eh) occurring over time; the nature of these changes is dependent on many other factors.

Sediment Texture

Sediment texture showed some relationship to nutrient and metal release for the Richmond site. Sandy (porous) sediments which contain a high organic content seemed to release higher levels of iron and manganese than did sediments of similar organic content. Zinc release was greatest from the fine-grained sediments, while background water cadmium concentrations appeared to decrease while dredging the fine-grained solids. Ammonium nitrogen concentrations in influent slurries from the Richmond site were closely related to the total organic nitrogen content of the sediments.

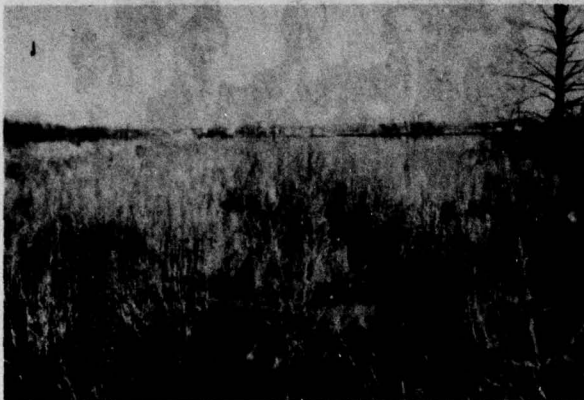
Geochemical Partitioning

The geochemical phase partitioning data for influent and effluent solids showed that some metals exhibited noticeable phase changes during their migration through land containment areas, while other metals showed little change. Also the shifts in each phase differed for each element.

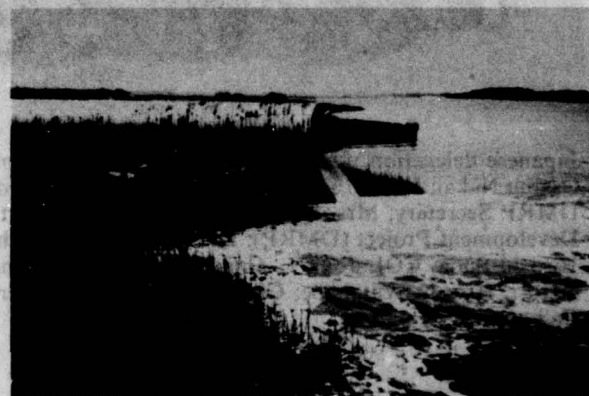
The exchangeable and carbonate phases could be considered as the most available to organisms, although the source for most phase shifts under oxidizing conditions results from the oxidative breakdown of sulfide and organic complexes. About a third of the solids-bound calcium and sodium were removed during extraction of the exchangeable phase, with measurable increases of exchangeable calcium, sodium, copper, and arsenic noted in effluent solids. Most of the metals showed increases in their carbonate phase

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Compartmentalized disposal area
on the Duwamish Waterway,
Seattle, Washington



Overland-flow system in disposal
area on Eagle Island near
Wilmington, North Carolina



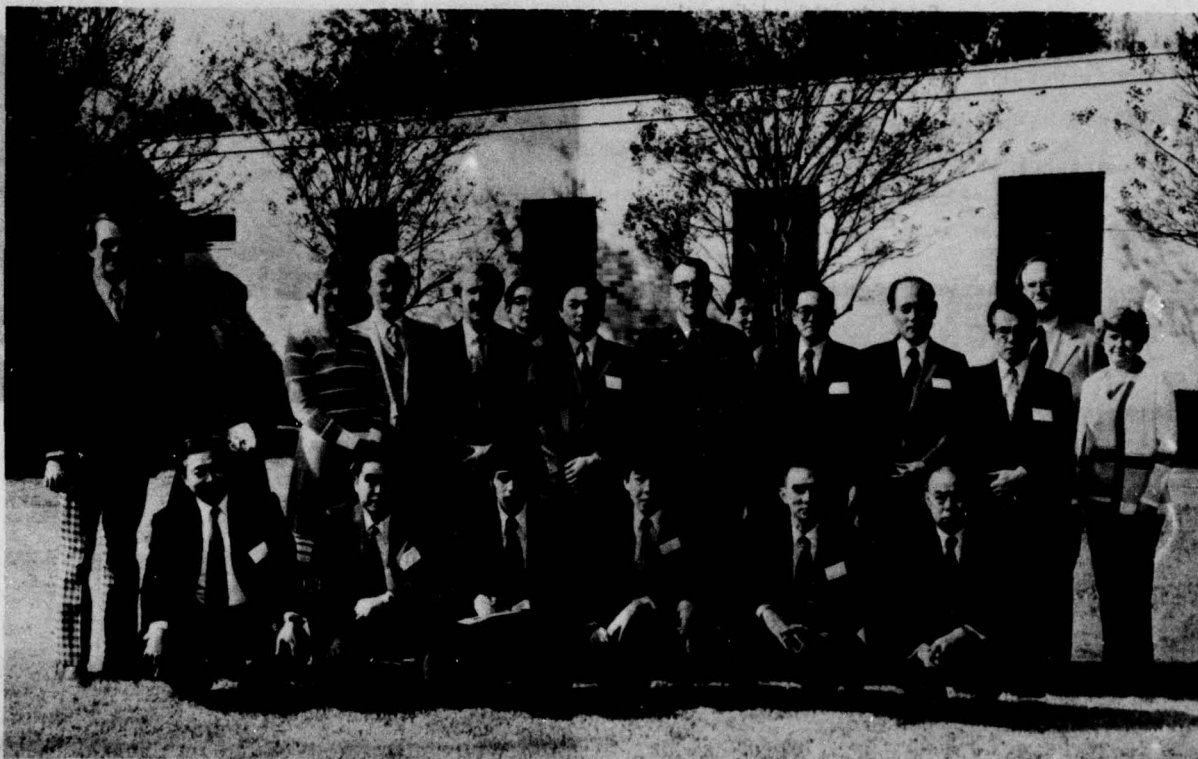
Effluent from Southport,
North Carolina, disposal area



Discharge from Lake Charles,
Louisiana, disposal area

Confined land disposal areas vary in size, configuration, and physical features. The small, barren, compartmentalized disposal area on the Duwamish Waterway and the large, vegetated, overland-flow system on Eagle Island are contrasting examples of such variation.

The effluent discharged from confined land disposal areas can vary widely in solids content, sometimes of drinking-water clarity (Southport site). The discharge from the Lake Charles site was characterized by high turbidity and solids content resulting from a short residence time, turbulent flow near the discharge weir, and a high concentration of oily residues. Both effluents were comparably low in dissolved oxygen; the clear effluent actually contained much higher soluble-phase concentrations of most heavy metals.



Japanese delegation visits WES—(Kneeling, l-r) Motoki Kondo; Dr. Takashi Otsuki; S. Sasamoto (interpreter); Osamu Nakai; Hiromi Koba; Dr. Tatsuo Yosida; (standing, l-r) Dr. Spencer A. Peterson, EPA; Ms. Linda Parker, DMRP Secretary; Mrs. Robert M. Engler; Dr. Robert M. Engler, Manager, Environmental Impacts and Criteria Development Project (DMRP); Dr. John Harrison, Chief, Environmental Effects Laboratory; Yasutako Kameda; Hiroshi Suda; COL John L. Cannon, Commander and Director, WES; Dr. Motoo Fujiki; Hajime Ito; Makoto Natori; Hiroshi Watanabe; Charles Calhoun, Manager, Disposal Operations Project (DMRP); and Mrs. Charles Calhoun.

THIRD MEETING OF U. S./JAPANESE EXPERTS

The Third Meeting of United States/Japan Experts on Management of Bottom Sediments Containing Toxic Substances was held in Easton, Maryland, in November 1977. Included on the Japanese delegation's agenda was a visit to the Waterways Experiment Station.

The meeting is held annually with its location alternating between the United States and Japan. The purpose of the meetings is to transfer technologies developed in the two countries and to maintain coordination of research and development in the field of bottom sediment management. The delegations are made up of government officials, representatives of the dredging industry, and researchers from universities, and private and government organizations. The meeting

in Easton was co-chaired by Mr. Hiroshi Suda of the Japan Ministry of Transport and Dr. A. F. Bartsch of the U. S. Environmental Protection Agency (EPA), Corvallis Environmental Research Laboratory. Mr. Charles C. Calhoun, Jr., Manager of the Disposal Operations Project, and Dr. Robert M. Engler, Manager of the EICDP, were members of the U. S. delegation and presented papers detailing results of the DMRP.

The papers presented at the Easton meeting are listed below and will be published as part of the EPA Ecological Research Series. Proceedings from the second meeting have been published and are available on request from the Director, U. S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, 200 S.W. 35th Street, Corvallis, Oregon 97330.

Title	Author
Toxic Substances Control Act: How it Affects EPA from a Research and Enforcement Standpoint	Steve Jellinek, Assistant Administrator for Toxic Substances, EPA
Current Status and Future Prospect on Water Works in Rivers and Lakes	Hiroshi Suda, Director, Environmental Protection Division
Aspects of Kepone Feasibility Study on the James River	Kenneth Mackenthun, Director, Criteria and Standards Division, Office of Water Planning and Standards, EPA
Turbidity Generated by Dredging Works	Osamu Nakai, Bureau of Ports and Harbors, Ministry of Transport
PCB Contamination of the Hudson River: Problem, Settlement, Study Plans, and Restoration Activities	Leo Hetling, Director, Department of Environmental Conservation, State of New York
Dredging Work of Sediment in Yokkaichi Port	Hajime Ito, Yokkaichi Port Authority
Analysis of the Organics and Pesticide Contents of Sediment from Lake St. Clair, the Detroit and Saginaw Rivers and Marinette-Menominee and Waukegan Harbors	Karl Bremer, Region V, EPA
Methylmercury Accumulation into Fish	Motoo Fujiki, University of Tsukuba
Impacts Associated with Discharge of Open Water Dredge Materials	Robert Engler, DMRP
Relationship Between Sediments and Benthos in Mikawa Bay	Takashi Otsuki, Japan Dredging and Reclamation Engineering Association
The Toxicity of Dredged Material to the Marine Macrobenthos	Richard Swartz, Chief, Newport Field Office, EPA
Fluidmechanical Study on the Pollution of Lakes	Tatsuo Yoshida, Japan Bottom Sediment Management Association
Eutrophication Control: Importance of Internal Phosphorus Supplies	D. Phillips Larsen, Corvallis Environmental Research Laboratory, EPA
Recent Progress in Management Techniques of Contaminated Bottom Sediments	Hiroshi Koba, Japan Dredging and Reclamation Engineering Association
The Regulation Guidelines and Criteria for the Discharge of Dredged Material: Prediction of Pollution Potential	Robert Engler, DMRP
Discharge Control of Toxic Substances and Management of Bottom Sediment Containing Toxic Substances	Toru Hayashi, Water Quality Bureau, Environment Agency
Treatment, Densification, and Management of Dredged Material Disposal Areas	Charles Calhoun, DMRP

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concentrations as a result of confined disposal.

Influent solids generally showed high carbonate phase values for cadmium and manganese, while zinc, cadmium, manganese, lead, copper, and sodium showed major increases in effluent solids. Carbonate phase cadmium, zinc, and manganese contributed 57, 33, and 20 percent to total concentrations of each respective element in the effluent solids. Iron, manganese, cadmium, and copper increased in the easily reducible phase of the effluent solids, although only manganese shows a major increase. Upon total digestion of the remaining solid phases, most metals (except for iron, nickel, and chromium) showed noticeable decreases in the digests.

A limited amount of data on the organic-sulfide phase (Seattle site) suggests that the noted decreases were mainly associated with reductions in organic and/or sulfide complexes during disposal area retention. Metals showing major phase changes include

manganese (easily reducible phase), cadmium (carbonate and easily reducible phases), zinc (carbonate phase), lead (carbonate phase), copper (carbonate phase), sodium (exchangeable phase), and calcium (exchangeable phase). Metals showing little change in phases during the solids retention time include chromium, nickel, mercury, potassium, and magnesium.

The geochemical phase partitioning findings, in conjunction with the previously discussed particle-size data, indicate that perhaps total acid digests of suspended solids should be included in any predictive test or effluent analysis rather than 0.45- μ m filtrates, especially since the impact of fine particulate matter on aquatic organisms is poorly understood at this time. However, bulk analysis of bottom sediments is not recommended as it has very little relationship to contaminant availability.

Prediction of Effluent Quality

The results of the diluted pore water and standard

These investigations are being conducted by Mr. Ronald E. Hoeppel of the EICDP. Coordination of this research with that dealing with open-water disposal is being done by Dr. Robert M. Engler, Manager, EICDP.

JOHN L. CANNON

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director



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